Kadirli Uygulamalı Bilimler Fakültesi Dergisi
Cilt 2, Sayı 2, 143-154, 2022

Journal of Kadirli Faculty of Applied Sciences
Volume 2, Issue 2, 143-154, 2022

Kadirli Uygulamalı Bilimler Fakültesi Dergisi

Journal of Kadirli Faculty of Applied Sciences

Evaluation of Egg Quality Traits and Nutrient Profile of Naked Neck, Rhode Island Red, Black Australorp and Their Crosses

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Research Article

Article History:
Received: 15.05.2022
Accepted: 25.08.2022
Published online: 09.12.2022

Keywords:
Birds genotypes
Egg geometry
Shape index
Egg quality analysis
Egg proximate composition

ABSTRACT

An egg is one of the most versatile and balanced food available for human consumption, being rich in proteins, fats, vitamins, and minerals. The study aimed to evaluate the genetic group (Rhode Island Red (RIR), Naked Neck (NN), Black Australorp (BAL) and their crosses (RIR*NN and BAL*NN)) effects on the external and internal quality parameters of eggs. A total of 75 layers were randomly distributed into five groups (15 birds from each genetic group). Each group was further sub-divided into three replicates (5 birds per replicate) in a randomized complete block arrangement. Birds of each replicate group were reared in a separate cage (10’ L × 8’ W × 4’ H) placed in the same shed. The experiment was continued for four weeks. All birds were fed on standard commercial layer diets and clean drinking water was provided all the time. Data on egg geometry, shape index, egg external, internal quality and proximate composition was recorded. The results revealed that the egg geometrical parameters of BAL and RIR were improved ($P < 0.05$). Notably, egg length of BAL was higher ($P < 0.05$), while egg breadth, egg volume and egg surface area was higher for BAL and RIR. Likewise, egg shape index was higher ($P < 0.05$) for BAL and RIR. Also, the egg weight, egg surface area, was higher ($P < 0.05$) and eggshell weight was lower for BAL and RIR. Moreover, yolk weight and yolk diameter was higher ($P < 0.05$) for BAL and RIR. However, the egg proximate composition did not alter ($P > 0.05$). The egg geometrical parameters, egg shape index and egg quality (external and internal) were significantly improved in BAL and RIR without interfering with the nutrient composition of the egg.

Çıplak Boyun, Rhode Island Red, Black Australorp ve Çaprazlarının Yumurta Kalite Özelliklerinin ve Besin Profilinin Değerlendirilmesi

Araştırma Makalesi

ÖZ

Makale Tarihçesi:
Geliş tarihi: 15.05.2022
Kabul tarihi:25.08.2022
Online Yayınlanma:09.12.2022

Anahtar Kelimeler
Tavuk genotipleri
Yumurta geometrisi
Şekil indeksi
Yumurta kalitesi analizi
Yumurta yaklaşık bileşimi

Yumurta, proteinler, yağlar, vitaminler ve mineraller açısından zengin olduğu için insan tüketimi açısından çok önemli ve dengeli gıdalardan birisidir. Çalışma, genetik grup (Rhode Island Red (RIR), Naked Neck (NN), Black Australorp (BAL) ve çaprazlarının (RIR*NN ve BAL*NN)) yumurtaların dış ve iç kalite parametreleri üzerindeki etkilerini değerlendirmeyi amaçlamıştır. Toplam 75 tavuk (her genetik gruptan 15 tavuk) rastgele beş gruba dağıtılmıştır. Her grup ayrıca rastgele bir tam blok düzenlemesinde üç tekrara (tekrar başına 5 hayvan) bölünmüştür. Her bir tekerrür grubunun tavukları, aynı kafese yerleştirilmiş ayrı bir kafeste (10' U x 8' G x 4' Y) büyütülmüştür. Çalışmaya dört hafta devam edilmiştir. Tüm tavuklar standart ticari yumurtacı yemleriyle beslenmiş ve her zaman temiz içme suyu sağlanmıştır. Yumurta geometrisi, şekil indeksi, yumurta dış, iç kalite ve yaklaşık kompozisyon verileri kaydedilmiştir. Sonuçlar, BAL ve RIR'nin yumurta geometrik parametrelerinin iyileştiğini ortaya koymuştur ($P < 0.05$).Özellikle, BAL'nin yumurta uzunluğu daha yüksek ($P < 0.05$) iken; yumurta genişliği, yumurta hacmi ve yumurta yüzey alanı BAL ve RIR için daha yüksek tespit edilmiştir. Aynı şekilde, BAL ve RIR için yumurta şekil indeksi daha yüksek bulunmuştur ($P< 0.05$). Ayrıca BAL ve RIR için yumurta ağırlığı, yumurta yüzey alanı daha yüksek ($P < 0.05$) ve yumurta kabuğu ağırlığı daha düşük gözlenmiştir. Ayrıca, BAL ve RIR için sarı ağırlığı ve sarı çapı daha yüksek bulunmuştur ($P< 0.05$). Ancak yumurta yaklaşık bileşiminde herhangi bir değişiklik olmamıştır ($P> 0.05$). Yumurtanın yaklaşık besin madde içeriğine müdahale etmeden BAL ve RIR'de yumurta geometrik parametreleri, yumurta şekil indeksi ve yumurta kalitesi (dış ve iç) önemli ölçüde iyileştiği gözlemlenmiştir.

To Cite: Islam MB, Khan S, Ahmad N, Rafiullah, Khan K, Khan S, Alam W.. 2022. Evaluation of egg quality traits and nutrient profile of Naked Neck, Rhode Island Red, Black Australorp and their crosses. Kadirli Uygulamalı Bilimler Fakültesi Dergisi, 2(2): 143-154.

Introduction

Over history, an egg has been considered as a principal component of the human diet. Importantly, eggs are an inexpensive, widely available and easily digestible food source of high-quality protein for humans. Eggs are known to be one of the complete diets and the 2nd greatest source of animal protein for humans (Miranda et al., 2015; Kumari et al., 2020). The egg contains many vital nutrients and its quality is accepted by the consumer due to many characteristics like its freshness, cleanliness, shell quality, haugh unit, albumen, yolk index and its nutrient profile. Mostly the quality of the egg is judged by its external and internal features. The former included the weight of the egg, egg geometry, weight of shell, color of the egg and specific gravity. The later one contains parameters like albumen, yolk, and yolk albumin ratio. Literature shows that several factors affect the quality of egg such as hen genetic makeup, nutrition, age, production system and egg oviposition time (Ahmadi and Rahimi, 2011; Yang et al., 2014). Predominantly, the egg weight and eggshell characters are mainly influenced by genetic makeup of the birds (Tumova et al., 2007). Essentially, these egg quality traits are vital in the breeding of poultry, chick's quality, growth and yield characteristics for the upcoming generations.

Egg geometry includes the surface area and volume estimation which are important factors in the poultry industry. On the other hand, egg shape index is an important factor for egg quality determination. The egg shape index has a positive correlation with the albumen quality (Rathert et al., 2011). Many research studies establish a correlation among egg shape index with thickness of the egg shell, length of albumin, width and height (Abanikannda et al., 2007; Olawumi et al., 2008; Rathert et al., 2011). The eggshell strength is affected by its surface area, specific gravity, volume, mass, thickness, microstructure, and percentage of the shell of the egg. Recently many researchers have taken interest in egg shape (Nedomova et al., 2009). The shape of the egg can be evaluated in 2 ways i.e. mathematical equations and different indices, which show variation of proper shape from specific models. Egg shape can be characterized by 2 indices i.e. length of egg to egg width ratio (shape index) and the ratio of the longitudinal axis of a lengthy and small section of the egg after dissection by the maximum diameter axis. Keeping in view the importance of egg shape and its quality indices, the present study was conducted to evaluate the effects of birds genotypes like local Naked Neck and exotic breeds of Rhode Island Red and Black Australorp and their crosses for egg geometry, shape index and egg quality parameters.

Materials and Methods

Experimental protocol and birds' husbandry

For this study, a total of seventy-five healthy layers (average age, 34 weeks) of different genotypes were selected randomly based on its health status, body condition score and homozygosity i.e Crosses having naked neck character was used for the experimental trial according to the project requirements. The genotypes comprise of Naked Neck (NN), Rhode Island Red (RIR), Black Australorp (BAL), and their Crosses (♀NN x ♂ RIR and ♀ NN x ♂BAL). Each genotype was kept in a separate group (15 birds per group). Each treatment group was further sub-divided into three replicates group (5 birds per replicate) based on randomized complete block design. Each replicate group was kept in the same shed and a separate cage (10' L × 8' W × 4' H). All birds were restricted feed (105 g feed/bird/d) on standard commercial layer diet. Moreover, clean drinking water was available to all birds all the time. A 16/08 light/dark period was provided to the birds. The experiment lasted for four weeks. The study was pre-approved by the board of studies meeting of the Department of Poultry Science, The University of Agriculture, Peshawar, on the approval of its ethical committee for live birds handling and management.

During the study period, eggs were collected and analysed on a daily asis, a total of 75 eggs per group (25 eggs per replicate group) were collected and analysed for the quality parameter and nutrient analysis. Prior to analysis, eggs were cleaned for any debris, filth, or fecal material with the help of nylon cloth and marked accordingly. The quality parameters of the egg were investigated by the application of different mathematical tools and formulas.

Egg geometry traits and egg shape index

Egg geometry parameters were calculated based on the maximum longitudinal egg length (L) and breadth (B) that were recorded with the help of a vernier caliper. Measurements were taken in centimeters. While, the volume of egg and egg surface area was estimated by the following formula by Narushing VG., 2005

$$\text{Volume (cm}^3) = (0.6057 - 0.0018\text{ B})\text{ L B}^2$$

$$\text{Surface area } (cm^2) = (3.155 - 0.0136\text{ L} + 0.0115\text{ B})\text{ L B}$$

Correspondingly, the egg shape index was measured from egg maximum length (L) and egg breadth (B), using the following formula.

Egg shape index (ESI) = Ratio between egg maximum breadth with that of maximum length times 100.

$$ESI\ (\%) = B/L \text{ x } 100$$

Egg quality parameters

The external egg quality traits included egg weight, eggshell weight, shell Ratio, shell thickness, Unit surface shell weight by the method of Inca et al., 2020.

The individual's already marked egg was weighed using digital balance to the nearest accuracy of 0.01 g. The egg was gently broken with the help of scissors and the eggshell was separated and cleaned with the tissue paper/cotton swab, after the removal of the inner shell membranes the eggshell was air-dried for 24 hours. After drying the eggshell was weighted by using a digital scale. Shell ratio is the ratio of shell weight to egg weight times a hundred. Mathematically, $Shell\ ratio\ (\%) = \text{Shell weight/Egg weight x 100}$

Shell thickness was measured through an already adjusted screw gauge from error (L.C= 0.01mm). The reading was taken from four pieces of eggshells one each from two ends (narrow and broad) and two from the egg body and was averaged to the nearest value of 0.01mm. The unit surface shell weight measured in g/cm^2 is the ratio of egg weight to egg surface area. Mathematically,

$$\text{Unit surface shell} = \text{Egg weight/Egg surface area}$$

The egg internal quality parameters consisted of albumin diameter, albumin height, albumin weight, albumin Index, albumin ratio, yolk weight, haugh unit, yolk Index, yolk ratio, and yolk albumen ratio.

Albumin diameter is the ratio of length and width of albumen in centimeters, and was determined with the help of vernier calipers.

$$Albumin\ diameter = [\text{Albumin length} + \text{Albumin breadth}]/2$$

Albumin height was calculated by inserting a transparent plastic ruler at different areas of albumin (egg white), and the data were recorded as average. The albumin weight was calculated by using the following formula.

$$Albumin\ weight\ (g) = Egg\ weight - (\text{Shell and shell membrane weight} + \text{Yolk weight})$$

Albumin Index was determined by the following formula

$$Albumin\ index\ (\%) = \text{Albumin height}/([\text{Albumin length} + \text{Albumin breadth}]/2) \text{ x } 100$$

Likewise, albumin ratio was calculated as:

$$Albumin\ ratio\ (\%) = \text{Albumin weight/Egg weight x100}$$

The yolk was separated by using a 1.5 liter plastic bottle through suction. The separated yolk was weighted via digital balance after careful removal of chalazae. The height of the yolk was measured at 3 or 4 locations and then average value was determined. The haugh unit was calculated by using the following formula.

$$\text{Haugh unit} = 100 \log (\text{H} + 7.57 - 1.7\text{W}^{0.37})$$

Where, H is the albumen height (mm) and W is the weight of the egg (g).

Yolk index, yolk ratio and yolk albumen ratio was estimated by using the following mathematical equation.

$$\text{Yolk index } (\%) = (\text{yolk height/yolk length} + \text{yolk breadth}/2) \text{ x } 100$$

$$\text{Yolk ratio } (\%) = (\text{Yolk weight/Egg weight}) \text{ x } 100$$

$$\text{Yolk a; bumen ratio } (\%) = \text{weight of yolk/weight of albumen}$$

Egg proximate analysis

Moisture, crude protein (CP), ether extracts (EE), nitrogen-free extract (NFE), and ash were determined according to the standard methods (AOAC, 2000). Ash content was determined at 550 ºC. Crude nitrogen was found out by the Kjeldahl method and crude protein was evaluated by multiplying the value of nitrogen with factor 6.25.

Statistical Analysis

Data showing the effects of genotypes of laying birds on the egg quality parameters and its proximate composition were analyzed by the PROC MIXED method of the Statistical Analysis System (SAS Institute, 2009). The effects of genotypes were considered as fixed effects and egg quality parameters were considered as random effects. The model used was:

$$Yij = \mu + Txi + \epsilon ij$$

Where, Y*ij*, is the yield, μ represent general mean, *Txi* is the fixed effects of genotypes and ϵij is the random error. Data was considered significant if P-value is less than 0.05.

Results

Data in Table. 1 describes egg geometry parameters and egg shape index of different layer genotypes like indigenous Naked Neck (NN), Black Australorp (BAL), Rhode Island Red (RIR) and their Crosses that includes Naked Neck Cross Black Australorp (♀NN*BAL♂) and Naked Cross Rhode Island Red(♀NN*RIR♂). Egg length, its breadth, volume, and surface area were found higher (P<0.05) for eggs of BAL and RIR. Similarly, the shape index was higher (P<0.05) for BAL and RIR.

Table 1. Effects of different genotypes of chicken on the egg geometry and shape index analysis (Mean ± SE)

	Genotypes					
Parameters	**NN**	**BAL**	**RIR**	**♀NN*BAL♂**	**♀NN*RIR♂**	**Sig.**
Egg length (cm)	5.13^{c}±0.08	5.47^{a}±0.08	5.43^{ab}±0.03	5.31^{abc}±0.04	5.25^{bc}±0.01	*
Egg breadth (cm)	3.80^{c}±0.05	4.33^{a}±0.03	4.26^{a}±0.06	4.09^{b}± 0.05	4.03^{b}±0.09	**
Egg volume(cm^3)	44.4^{c}±1.72	61.5^{a}±1.54	59.2^{a}±1.68	53.3^{b}±1.42	51.2^{b}±0.24	**
Surface area (cm^2)	61.1^{c}±1.58	74.2^{a}±1.44	72.7^{a}±1.00	68.1^{b}±1.01	66.3^{b}±0.22	**
Shape Index (%)	74.1^{b}±1.38	79.2^{a}±1.26	78.6^{a}±1.52	77.0^{ab}±1.21	76.8^{ab}±0.34	**

In the same row, values carrying different superscript letter ($^{a, b, c}$) means significant difference at P<0.05.; SE, standard error; *, P<0.05; **, P< 0.01

The data for the external egg quality parameters of different layer genotypes are presented in Table. 2. The egg weight and eggshell weight were found significantly (P<0.05) higher in BAL and RIR. Similarly, the egg surface area and unit surface shell area were also found significantly different (P<0.05), with higher value for BAL and RIR. The eggshell ratio was significantly (P<0.05) higher in NN followed by NN*BAL.

Table 2. The internal egg quality parameters (Mean ± SE) of different bird's genotypes and their crosses

Parameters	Genotypes					Sig.
	NN	BAL	RIR	♀NN*BAL♂	♀NN*RIR♂	
Egg weight (g)	43.5^{c}±0.78	57.3^{a}±0.91	58.1^{a}±0.26	49.7^{b} ±0.24	50.1^{b} ±0.63	**
Egg surface area (cm^2)	61.1^{c}±1.58	74.2^{a}±1.44	72.6^{a}±1.00	68.1^{b}±1.01	66.3^{b}±0.22	**
Unit surface shell area (g/cm^2)	0.71^{c}±0.002	0.77^{ab}±0.001	0.80^{a}±0.003	0.72^{bc}±0.001	0.75^{bc}±0.004	*
Eggshell weight (g)	4.90^{c} ±0.05	5.53^{a} ±0.14	5.60^{a} ±0.01	5.27^{b} ±0.02	5.29^{b} ±0.02	**
Eggshell weight (%)	11.3^{a}±0.23	9.66^{c} ±0.33	9.64^{c} ±0.01	10.6^{b} ±0.09	10.6^{b} ±0.08	**

In the same row, values carrying different superscript letters ($^{a, b, c}$) means significant difference at P<0.05.; SE, standard error; *, P<0.05; **, P<0.01.

The data of the egg internal quality parameters are presented in Table 3. Albumin weight, its diameter, and albumin ratio was higher (P<0.05) for BAL and RIR. On the other hand, albumin height and albumin index did not alter (P>0.05) among the birds' genotypes and their crosses.

Likewise, yolk weight and yolk height was higher (P<0.05) for BAL and RIR. Yolk ratio was found significantly (P<0.05) higher for NN followed by NN*BAL. The highest yolk albumin ratio was reported for NN followed by NN*BAL. On the other hand, yolk diameter and yolk index showed no significant (P>0.05) difference among the genotypes and their crosses (Table 4).

Table 3. The internal egg quality analysis (mean ± SE) of different bird's genotypes and their crosses

Parameters	Genotypes					Sig.
	NN	BAL	RIR	♀NN*BAL♂	♀NN*RIR♂	
Albumin weight (g)	24.7^{c}±0.67	35.1^{a} ±0.67	35.7^{a} ±0.49	29.1^{b} ±0.28	29.5^{b} ±0.62	**
Albumin diameter (cm)	10.3^{c} ±0.05	10.4^{a} ±0.08	10.4 ^{a} ±0.01	10.3^{b} ±0.01	10.4^{b} ± 0.03	**
Albumin ratio (%)	56.9^{c}±0.53	61.3 ^{a} ±0.76	61.4 ^{a} ±0.58	58.7^{b} ±0.28	58.9^{b} ±0.49	**
Albumin height (mm)	6.36^{b} ±0.31	7.30^{a} ±0.35	7.13^{a} ±0.03	6.70^{ab}±0.05	6.63^{ab} ±0.06	*
Albumin Index (%)	61.7^{b}±3.13	70.1^{a} ±3.35	68.4^{a} ±0.32	64.8^{ab}±0.56	63.9^{ab} ±0.64	*

In the same row, values carrying different superscript letter ($^{a,\ b,\ c}$) means significant difference at P<0.05.; SE, standard error; *, P<0.05; **, P<0.01

Table 4. Effect of different genotypes and their crosses on the egg yolk quality analysis (mean ± SE)

Parameters	Genotypes					Sig.
	NN	BAL	RIR	♀NN*BAL♂	♀NN*RIR♂	
Yolk weight (g)	13.8^{c}±0.14	16.6^{a}±0.52	16.8^{a}±0.25	15.2^{b}±0.03	15.2^{b}±0.06	**
Yolk height (cm)	1.40 ^{c}±0.05	1.55^{ab}±0.07	1.58^{a}±0.05	1.46^{c} ± 0.05	1.47^{bc}±0.03	**
Yolk ratio (%)	31.8^{a}± 0.40	29.1^{b}±0.58	28.92^{b}±0.56	30.7^{a}±0.19	30.56^{a}±0.40	**
Yolk Albumin Ratio (%)	55.9^{a} ±0.01	47.3^{c}±0.014	47.1^{c}±0.01	52.3^{ab}±0.005	51.9^{b}±0.01	**
Yolk diameter (cm)	3.76^{b}±0.08	4.01^{a} ± 0.09	4.06^{a}±0.08	3.86^{ab}±0.02	3.92^{ab}±0.05	*
Yolk index (%)	37.2±2.40	38.6±0.57	38.9±0.84	37.8±0.38	37.5±0.15	ns

In the same row, values carrying different superscript letter ($^{a,\ b,\ c}$) means significant difference at P<0.05.; SE, standard error; *, P<0.05; **, P<0.01; ns, non-significant

The data on the egg proximate composition such as moisture, crude protein (CP), ether extracts (EE), ash and nitrogen-free extract (NFE) of genotypes are presented in Table 5. Overall the egg proximate analysis resulted in the same chemical composition (P>0.05) among the genotypes and their crosses.

Table 5. Egg chemical composition (mean ± SE) of different genotypes and their crosses

Parameter	Genotypes					Significance
	NN	BAL	RIR	♀NN*BAL♂	♀NN*RIR♂	
Moisture	77.4±0.10	77.4±0.05	77.4±0.04	77.5±0.05	77.4±0.05	Ns
CP	11.8±0.11	11.6±0.14	11.6±0.13	11.5±0.02	11.7±0.10	Ns
EE	7.62±0.02	7.50± 0.07	7.53±0.07	7.67± 0.03	7.57±0.08	Ns
Ash	1.39±0.01	1.42± 0.03	1.40±0.02	1.39±0.02	1.39±0.01	Ns
NFE	1.05± 0.00	1.06±0.00	1.05±0	1.04±00	1.04±00	ns

In the same row, values carrying different superscript letter ([a, b, c]) means significant difference at $P<0.05$.; SE, standard error; ns, non-significant. CP, crude protein, EE, ether extract, NFE, nitrogen free extract

Discussion

Eggs are a versatile diet comprising essential elements for life activities. The composition of eggs has a similar index on the basis of nutrition of varying species, however, egg quality analysis and usage of eggs are only restricted mostly to chicken eggs. Egg quality characteristics countable for consumer acceptability are external quality such as freshness, cleanliness, egg weight, and eggshell strength. Similarly egg internal quality is important from an industrial perspective such as albumin index, yolk index and chemical composition In this study, the egg quality characteristics are determined in different layer genotypes like indigenous Naked Neck (NN), Black Australorp (BAL), Rhode Island Red (RIR) and their Crosses that includes Naked Neck Cross Black Australorp (♀NN*BAL♂) and Naked Cross Rhode Island Red(♀NN*RIR♂).

Egg geometry is a very important parameter for the poultry industry as well as for biological studies. Geometrical estimation and shape index of the egg of BAL and RIR was significantly higher than NN and NN*BAL and NN*RIR. Similarly, NN*BAL and NN*RIR had higher geometric values than pure NN. This higher variation in these values might be due to their improved genetic makeup. Our research findings are similar to the reported value of Chatterjee et al. (2007) who studied egg geometry, shape index, egg length and egg breadth of NN, white, black, and brown Nicobari birds. They reported that all the mentioned parameters for the eggs from naked neck layers were lower as compared to white, black, and brown Nicobari fowl. Similarly, Singh et al. (2009) and Rehman et al., (2016), found higher egg weight, egg geometry, egg shape index and egg volume for black Australorp and Rhode Island Red than other local breeds. However, Yakubu et al. (2008) reported a non-significant effect on egg weight, egg width, volume, surface area, shape index and internal parameters of NN and different indigenous breeds of poultry. Similarly, Rajkumar et al., (2009) found heavier egg width, length, shape index and volume for the Naked Neck layers as compared to white leghorn.

Quality of the egg is the key feature persuading the demand of people. Importantly, the external egg quality traits were significantly altered among the different genotypes. According to our analysis, improved value for egg weight, shell weight, and surface area were recorded for BAL and RIR. The findings of our study was consistent with the reported value of Islam and Dutta (2010), who stated lower value for NN breed as compared to the exotic breeds, conversely, Yakubu et al. (2008) reported higher weight of egg for birds from Nigeria than NN.

The egg albumen is a key indicator of the determination of the internal egg quality. In the present study, the albumin weight, its diameter and its ratio were improved in BAL, RIR followed by NN*BAL and NN*RIR. Our results findings are in line with the results of Islam et al. (2010) who reported lower albumin weight in NN birds. In contrast to our findings, Yakubu et al. (2008) reported lower albumin height in NN chicken from Nigeria. According to our analysis, the yolk weight was also improved in BAL and RIR. Islam et al. (2010) reported similar results to our findings who observed lower yolk weight in NN birds. Similarly, Chatterjee et al. (2007) reported higher yolk weights in NN chicken. Likewise, yolk albumin ratio was also found significantly different among genotypes of birds. Yolk the quality is predominantly connected to yolk weight and yolk index. Our findings are contrary to Chatterjee et al. (2007) who reported a lower yolk index in NN chicken of Andamans. The genetic correlations of yolk index with albumen index, yolk weight and albumen weight were high and positive while the same varied with shell weight and shell thickness (Duman et al. 2016). Importantly, the egg proximate composition of different genotypes (NN, RIR, BAL and their crosses) did not vary in the present study. Our results were supported by Song et al. (2000) as they found the similar composition of eggs in their study.

Conclusions

The findings of this study reported that the egg geometry, shape index, external and internal egg quality traits were significantly varied among the layer genotypes like indigenous Naked Neck (NN), Black Australorp (BAL), Rhode Island Red (RIR) and their Crosses that includes Naked Neck Cross Black Australorp (♀NN*BAL♂) and Naked Cross Rhode Island Red(♀NN*RIR♂) with no significant difference in its proximate analysis. Crossbreeding of indigenous NN breeds with BAL, RIR exotic breeds improved the egg quality parameters in their respective crosses.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

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